

## Audio/Video Inter-Device Power Control



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## Problems for A/V systems

### In a local network

- How do people manage starting and stopping content streams?
- How do people manage the power state of A/V devices?

### Context

- Many devices
- Dynamic networks
- Automatic functions
- Many users
- Multiple simultaneous streams
- Multiple displays per stream
- Diverging audio, video
- **Multiple technologies / stream**

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## Energy context

- Audio/video devices in US\*
  - About 140 TWh/year electricity (~ \$14 billion/year)
  - ~5% of buildings electricity
  - >3x data center electronics
- Power level reductions essential
  - On, sleep, off
    - Significant progress in last decade
- **Energy = power x time**
  - Need to address time dimension
    - Primary problem... products fully on but not needed

*Energy alone not enough*

*\*does not include PCs, monitors, or IP infrastructure*

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## Unsatisfactory approaches

- **Do nothing** (status quo)
  - Waste energy, annoy people
- **Command and control**, from:
  - Individual devices – based on their activity
  - Remote controls – based on requested function
  - Brittle, error-prone, not automatic, requires configuration, ...
  - Can't handle emerging usages
- **Single technology solutions**
  - Few buildings (will) have single technologies

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## The Solution — End Result

### Audio/Video Inter-Device Power Control (A/V PC)

- Distributed, self-control
- Automatic\* – default – no configuration

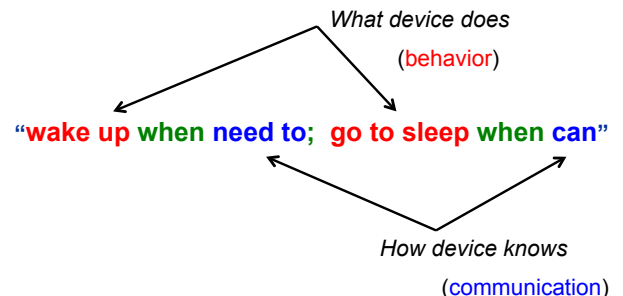
**“wake up when need to; go to sleep when can”**

**Goal: deliver energy savings AND more convenience**

*\*as much as possible*

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## The Solution — Devices



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## The Solution — Mechanism

### “Sleeping Streams”

#### Stream

- sequence of links across which A/V content is passed
- association among devices
- the whole stream

#### Today

- streams states: active or torn down

#### Proposal

- create a stream sleep state
- exists but is not active



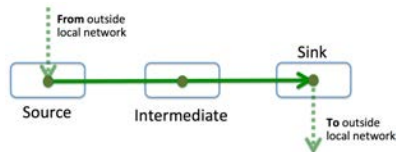
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## Assumptions

- Future devices will almost always toggle between on and sleep (rarely be off; have a sleep state)
- Future devices will retain network connectivity in sleep
  - Participate in protocols for discovery, etc.
  - Notice when events occur that should wake device
- Devices and technologies should not rely on the presence of central control
  - Does not rule out using central control; makes it simpler
- Streams will have names (for device and user use)
  - Users will know about stream names and sleep states
- Many streams will pass over more than one technology (e.g. IP, HDMI, and WISA)

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## Stream/Device dynamics



- A/V Streams
- Devices
- Links

- Actions
  - person or device
- Behaviors
  - response to action



- Transitions
- Power/stream states (on, sleep, off)

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## Example streams

- Movie in Living Room (finite)
- Sports all over (real-time)
  - Multiple displays (sinks)
- Door camera (w/ or w/o audio) (finite) (real-time)
  - Kitchen and living room display
- Skype call (finite) (real-time)
  - Kitchen display, camera
- Music everywhere

- Stream attributes: finite/not, real-time/not
- Multiple streams may converge on single display
- Recorded streams may involve no display

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## How would a sleeping stream work?

- Streams created only when all devices awake
  - Simplifies device discovery, security
- Multiple streams may be active at same time
  - (and many more asleep)
- Waking stream should be (much) faster than creating anew
- Each device knows identity of all other devices in stream
  - Even if don't share a technology
- Will need to be understood by users
  - Design user interaction from beginning

## Example Use Case: Wake Blu-ray Player (BD=Blu-ray Disk)

Step	BD	TV	Stream	Action and Behaviors
START	Sleep	Sleep	Sleep	
				BD power-up command (manual or internal timer) <b>or</b> manual play command
1	Wake			
2			Wake	BD wakes up last stream it participated in
3		Wake		Stream involves TV so TV must power up
4		Input		Change Input (if necessary)
5	Play		On	Start content (only after both devices fully wake; only applies to fixed streams)
END	On	On	On	

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## General sequence of Use Cases

- Initial device action (user or internal)
    - Stream action/behavior
    - Other device actions/behaviors
  - Initial stream action (user or internal)
    - Device actions/behaviors
- 
- Sequence does not end until all devices and stream exit transition states
  - Device power states linked by stream states

### Development process

- Created use cases
- Extracted behaviors
- Digested behaviors

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## Use case summary

### One-Device Cases

Device Powered Up  
 Device Powered Down (timer, manual, or presence of a signal)  
 Device Powered Down (signal or occupancy)  
 Device Put to Sleep (auto-power down)

### Two-Device Cases

Source powered up	Sink powered up
Fixed Source ends	Source paused
Sink switched away from source	Sink powered down
Source powered down	Sink switched to Source
Fixed Sink finishes	

### Three-Device Cases

Intermediate powered up	Intermediate powered down
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### Stream-focused Cases

Stream woken	Stream to sleep
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### Failure Cases

Failure on power on	Failure while active
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*Many other cases considered — did not introduce new behaviors*

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## Resulting behaviors – Sinks

### On

<u>Notified stream to go to sleep</u>	<u>Switched to different source/stream</u>
- Go to sleep	- Put old stream to sleep
	- Wake new stream
<u>Powered down</u>	<u>Switched to different input</u>
- Tell stream to go to sleep	- Tell old stream to go to sleep
	- Wake new stream
<u>Fixed sink ends</u>	
- Tell stream to go to sleep	

### Sleep

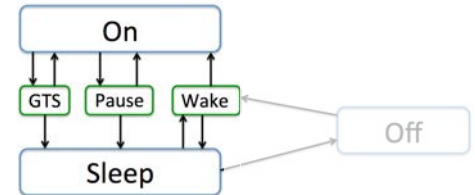
<u>Notified that a stream is waking</u>	<u>Powered up</u>
- Wake self	- Wake self
- Change input (if needed)	- Wake stream

*Also behaviors for: sources, intermediates, streams, failure*

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## Stream states

- Three long-term stable states
- Three intermediate states
  - Transition times
  - Final state uncertain
- Off means stream dismantled

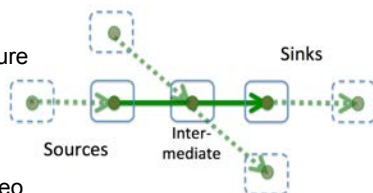


"GTS" = Going To Sleep

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## Also considered ...

- Multiple streams
- Named streams
- Multiple sinks and/or sources
- Creating streams
- Changing stream structure
- Failure
- Occupancy sensors
- Emergency broadcasts
- Diverging audio and video
- Sleeping intermediate devices
- HDMI switches
- Legacy devices



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## Summary

- Stream management is a problem
  - User experience
  - Energy
- Need common architecture
  - Simple concepts
  - Works across technologies
- Sleeping Stream concept appears to meet needs
  - Layer into existing standards; not new protocol

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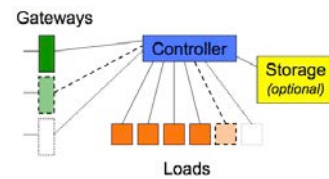
## Next steps

- Create overall standard — create CEA working group
    - Needed capabilities for protocols
    - Standard device behaviors
  - Add content to stream management standards
    - UPnP, HDMI, Airplay, ....
  - Add behaviors to devices
  - Explain to public
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- Save energy; deliver more convenience

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## Bonus Topic

### Local Power Distribution



- *Move from unitary grid to network model of power*
- *Technology to do for power distribution what the Internet did for communication*

more at: <http://nordman.lbl.gov>  
(or ask me)

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Thank you

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